Wide Area Integration: Innovation for the Virginia Class Submarine

Thomas P. Conrad
conradtp@csd.npt.nuwc.navy.mil

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Virginia (SSN 774) C3I System

(Pictorial of Attack Center)

Non-Propulsion Electronics System Challenges

Objectives

- **Affordability**

- **Meet Ship Schedule**

- **Meet Performance Requirements**

- **Mission Flexibility**

Trade-off Studies (1988-present)
Acquisition Reform Initiative
System Engineering

Key Technical Approach

- **Commercial-Off-The-Shelf Products**

- **Open Systems Architecture**

- **Non-Development Items**

- **Software Reuse**

- **Concurrent Engineering**

- **Modular Integrated Deck Structure/Structurally Integrated Enclosure**

- **Early Industry Involvement**

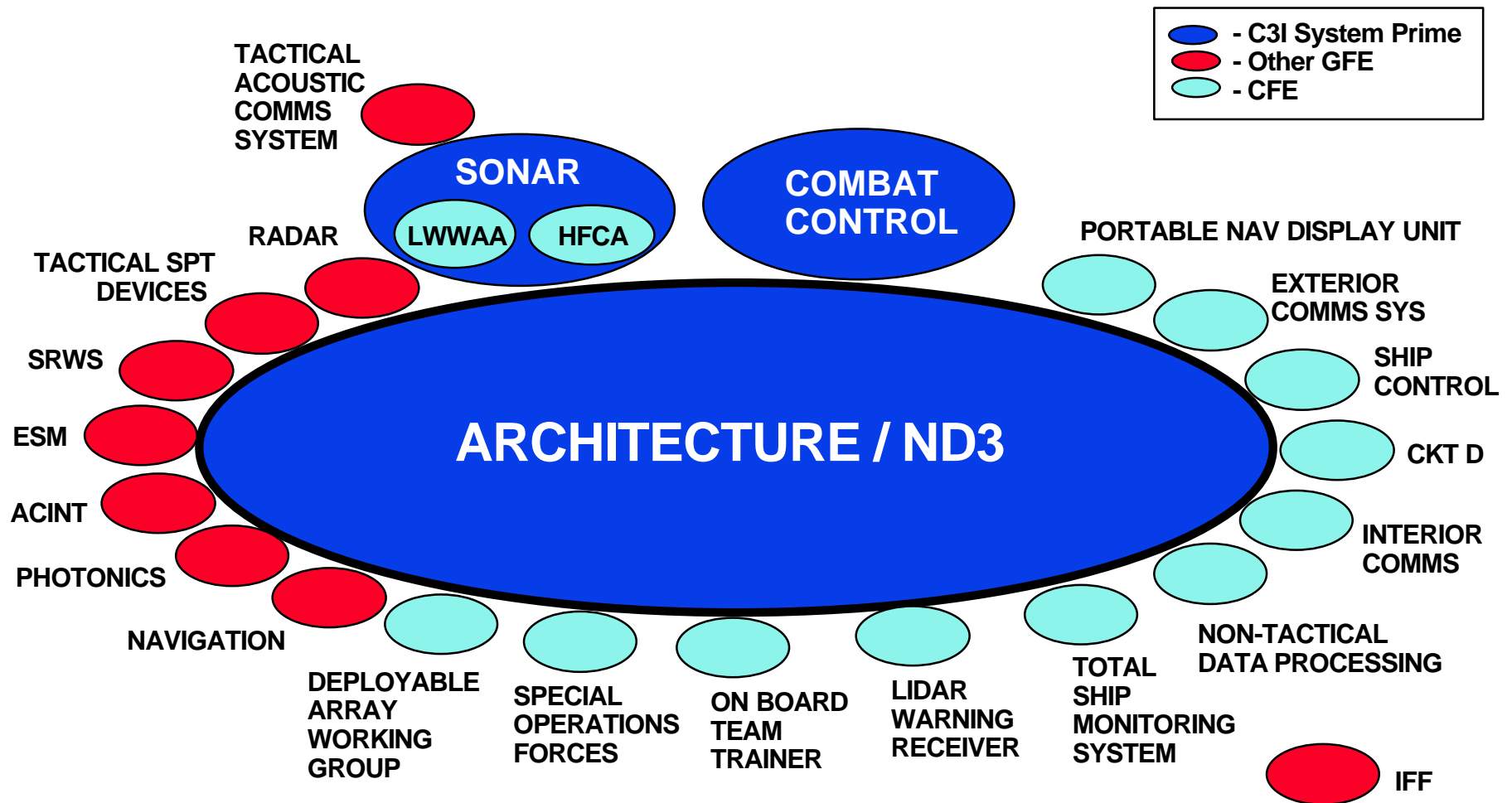- **Early Customer (Fleet) Involvement**

Context of the NPES Acquisition

- A System of Systems
- Federated Computing Resources
- Integrated Information Architecture
- Open System Architecture
- Based on COTS Technologies
- Multiple Parallel Acquisitions of Subsystems
- Early End-User Involvement

An Architecture-Based System

A Standards-Based Architecture

Non-Propulsion Electronics System:
- A System of Systems -

Legend:
- 🔵 - C3I System Prime
- 🔴 - Other GFE
- 🟢 - CFE

ARCHITECTURE / ND3

SONAR
- LWWAA
- HFCA

COMBAT CONTROL

TACTICAL ACOUSTIC COMMS SYSTEM

RADAR

TACTICAL SPT DEVICES

SRWS

ESM

ACINT

PHOTONICS

NAVIGATION

DEPLOYABLE ARRAY WORKING GROUP

SPECIAL OPERATIONS FORCES

ON BOARD TEAM TRAINER

LIDAR WARNING RECEIVER

TOTAL SHIP MONITORING SYSTEM

NON-TACTICAL DATA PROCESSING

INTERIOR COMMS

CKT D

SHIP CONTROL

EXTERIOR COMMS SYS

PORTABLE NAV DISPLAY UNIT

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12/1/98

Innovative Integration Approaches

Platform Level Approaches

¤ Command and Control Systems Module
¤ Structurally Integrated Enclosure
¤ CCSM Off-Hull Assembly and Test Site (COATS)

Architecture Oriented Approaches

¤ Formal Architecture Definition Process
¤ Risk Reduction Process
¤ Architecture Topology Definition

Software/System Approaches

¤ Software-Based Interface Technology
¤ Data-Oriented Versus Point-To-Point Interfaces
¤ Wide Area Integration

The Problem of Integration

- **NPES is a Large, Complex, Software-Intensive, Real-Time, Mission-Critical, Man-Machine System.**

- **Affordability Considerations Preclude Establishment   of a Traditional Land-Based Integration Test Site.**

- **Scope of the System and the Acquisition Approach Mandate Multiple, Spatially Distributed Development Sites.**

- **There is Substantial Risk in Deferring Integration Test Until the System is Assembled Dockside.**

New Approach

- **Take Advantage of Emerging Network-Centric Development Technology.**

- **Take Advantage of the System's Client-Server Architecture and Data-Oriented Interfaces.**

- **Plan for Incremental Integration - Integrate Early and Often.**

Define and Implement a Wide Area Integration Capability

Wide Area Integration Facility (WAIF) Definition

The WAIF is the set of hardware and software that serves as the fabric which connects NPES Subsystems to form a virtual development and test facility . This facility will have the capability of emulating the COATS system configuration for test and evaluation purposes.

NPES: Non-Propulsion Electronics System
COATS: CCSM Off-Hull Assembly and Test Site

WAIF Implementation

(WAIF Diagram of Interconnections)

Benefits of WAIF

- **The Investment in the WAIF As an Early Integration Mechanism Will Provide an Estimated Return On Investment of ~ 3.7 When Compared to the Projected Cost Growth to the Program (Absent the WAIF) to Fix Problems Associated With Integration of NPES.**

- **The Use of WAIF and COATS Will Significantly Reduce the Risk of Failing to Achieve Successful Integration on Schedule. Without WAIF, the NPES Ability to Complete a Successful Integration at COATS (Within Cost and Schedule) Is Considered a High Risk.**

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WAIF Utility (Pre-COATS)

- **Facilitate Early Subsystem Interface Development and Test, Both Formal and Informal**

- **Serve As Pre-COATS Facility for Development and Test of System Management Functions**

- **Facilitate Pre-Configuration of Subsystems Prior to Delivery at COATS**

    - **Network Configuration Could Consume 1 Month Out of 9 Months of Costly COATS Test Time**

- **Support Subsystem Internal Development Testing**

    - **Architecture Subsystem Test Procedure Development and Internal Test Conduct**

    - **Sonar to CC Testing Through September 98**

- **Dry Run COATS Test Procedures**

WAIF Utility (COATS)

- **Remote Troubleshooting**

- **Software Updates Provided from Developer's Site**

- **Support FFR Activities**

- **Support Secure VTC Linking COATS to Developer's Sites**

- **Potential Link to Tactical Ship Control System at COATS**

New Challenges for Software Integration

- **It Is a Difficult Task to Integrate a Large Complex Real-Time Software System Even When the System Is Built to a Detailed Requirements Specification With Full Design Disclosure.**

- **Consider the Increase in Difficulty When the System Is Assembled From Reused Components, Many of Which Were Built to Serve Broader Marketplace Needs and for Which No Design Disclosure at All Is Available.**

Innovative Platform-Level Approaches

- **Command and Control Systems Module (CCSM)**
  - **Shock Isolated Deck Structure**
  - **Modular Construction**
  - **CCSM Off-Hull Assembly and Test Site (COATS)**

- **Structurally Integrated Enclosure (SIE)**
  - **Standard Rack**
  - **Hotel Functions (e.g. water, power, grounding)**
  - **Maximizes Useable Volume**

- **Fiber Optic Cable System (FOCS)**
  - **Standardized Cable Plant**
  - **All Fiber Cabling for NPES**
  - **Reconfigurable for Future Needs**

NPES Architectural Integration

- **Architecture Definition Process**
  - **Maximum Industry Involvement in the Design of the C3I System Architecture**
    - » **Three Industry Architects Hired (BBN, TRW, AT&T)**
    - » **Architecture Recommendations Generated**
- **Risk Reduction Process**
  - **Architecture Working Group**
  - **Open Systems Critical Item Tests**
- **Architecture Topology Defined**

Integration Approaches

- **Software-Based Interface Technology**
  - Common Object Request Broker Architecture (CORBA)
  - Object-Based Software Interfaces
  - Software "bus"
  - Location, Language, Implementation, Processor Independence

- **Interfaces Are Data-Oriented Versus Point-to-Point**
  - Data Groups
  - Integrated Product Teams
  - Common Interfaces: 16 Group Interfaces Derive 96 Point-to-Point Interfaces

- **Wide Area Integration**
  - Integrate Early and Often - Risk Mitigator
  - Wide Area Integration Facility (WAIF)
  - Leverages Facilities at all Development Sites
  - Extends Development Facilities into COATS